Advancing Architecture-Centric Practices in US Army Acquisition

Presented at SSTC 2010

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DoD Systems are Increasingly Complex…

…Systems of Systems (SoS) even more so
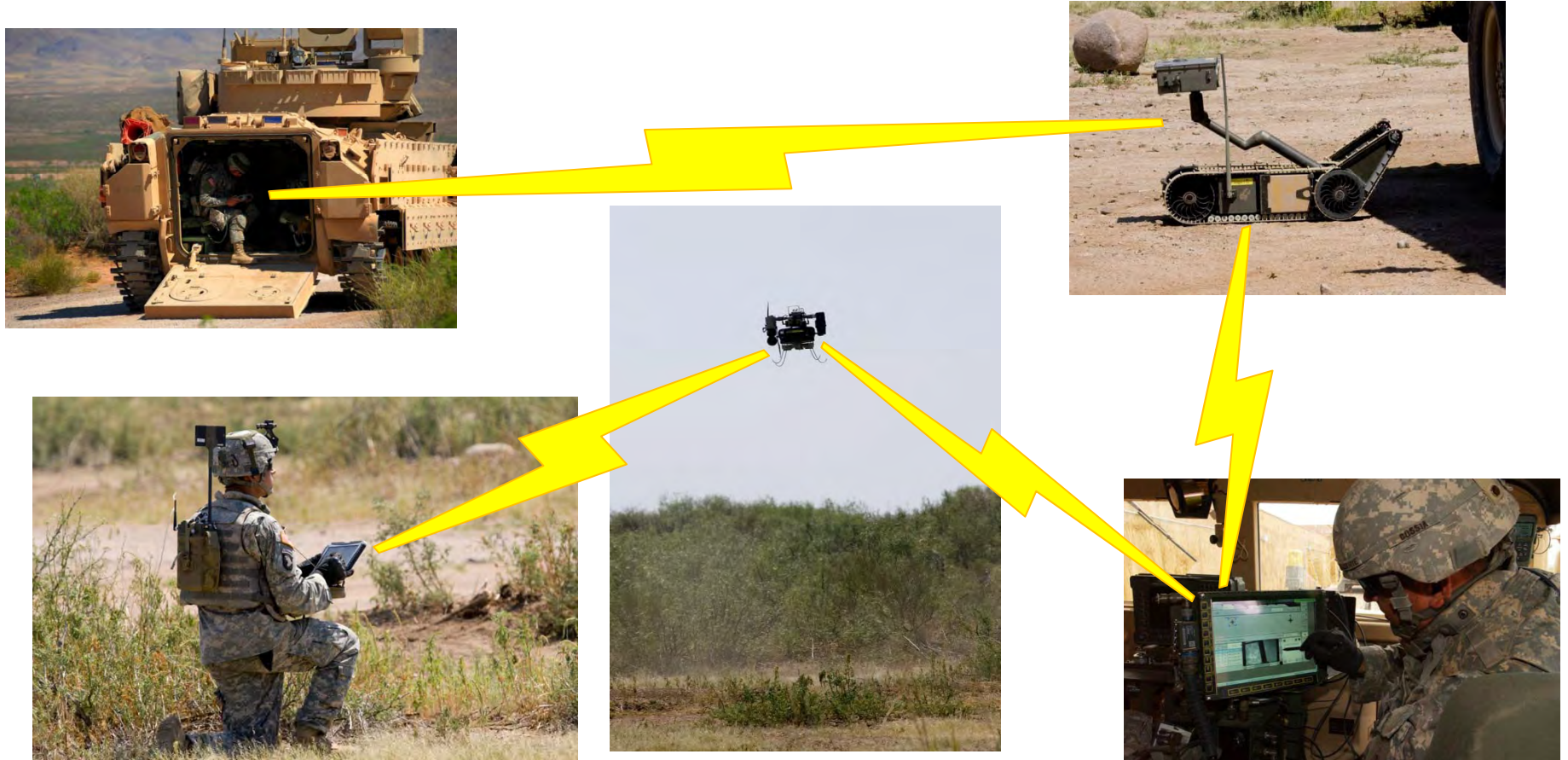
More and more, software is the integrating element in all manner of systems…

Software is Ubiquitous in Army Systems

Some systems are almost exclusively software

Systems like FBCB2 are *software systems*, i.e., systems whose primary functionality is derived totally (or nearly so) from software.
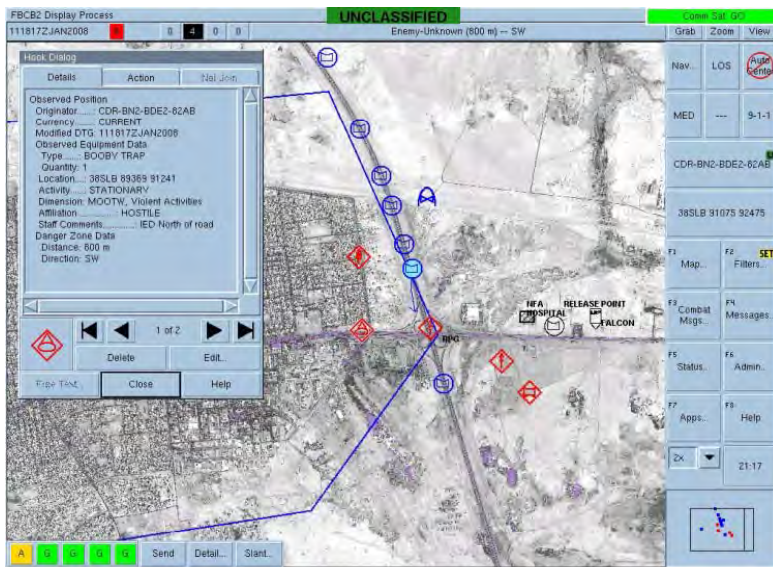
Software-reliant systems can be harder to identify

Systems like the Abrams tank are *software-reliant*: they depend on software for critical functions such as navigation, accurate fires, network communication, etc.

Coping with System/Software Complexity is a Must

2008-2009 Interviews with Army PEOs

- Relationship between system engineering and software engineering is driving system complexity
- *Example*: Army Software Blocking/Network Capability Sets - decade-long attempt to horizontally integrate Battle Command software across brigade elements
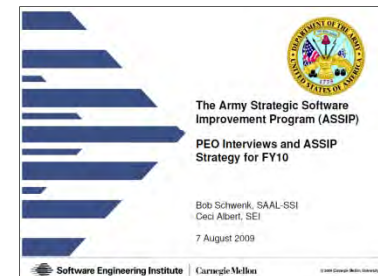
2009 NASA Study

- Software complexity leads to system and operational complexity (and increases risk)
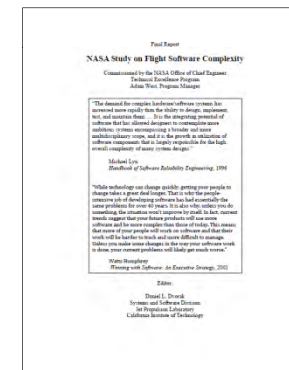
2009 MIT Study

- Software causes systems to be become "interactively complex" (intellectually unmanageable)
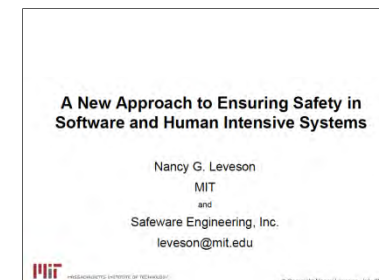
Architecture-Centric Practices are Key…

Defense Science Board (1994 & 2000)

- Software architecture techniques can <u>reduce cost and cycle times</u>
- Architecture is "a central theme for software reuse, product lines, and greater exploitation of commercial technology and practices"

Army Workshop on Weapon Software Upgrade Programs (2001)

- Architecture is "a key technical focus for the system"
- Architecture is critical in determining the future ability to upgrade the system
- In 2008, GAO testimony noted similar findings for DoD business systems

NASA (2009)

- "Good software architecture is the most important defense against incidental complexity in software designs, but good architecting skills are not common"
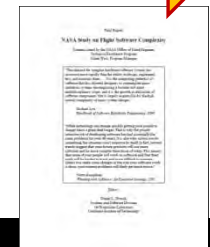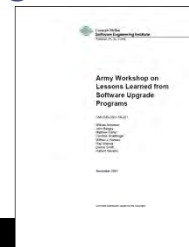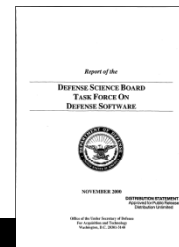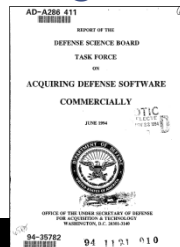
DoD Tri-Service Assessment Initiative (2003)

- Review of 21 DoD program assessments
  - poor software architecture practices are one of the
    systemic causal factors of software-reliant systems issues
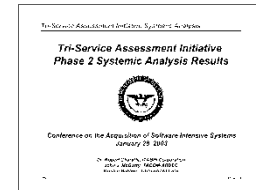
SEI surveys and interviews of Army PMs and PEOs (2004 & 2005)

- PMs/PEOs felt prime contractors' software architecture
  abilities were only about average
  - Yet, they also felt government program office staffs were
    not sufficiently skilled to evaluate software architectures
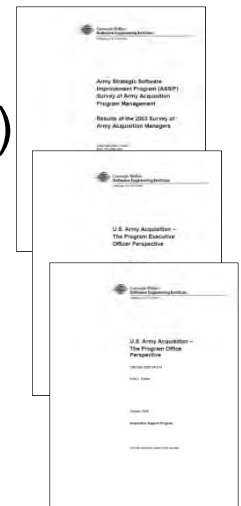
SEI analysis of results from 18 architecture evaluations (2006)

- \>50% of the programs had significant *program* risks driven by
  lack of architecture training/tools and poor architecture planning
- ~2/3 of risks discovered were risks of *omission*
  - *e.g.,* architectural decisions either not made or not captured

On DoD projects, all too often the SEI sees…
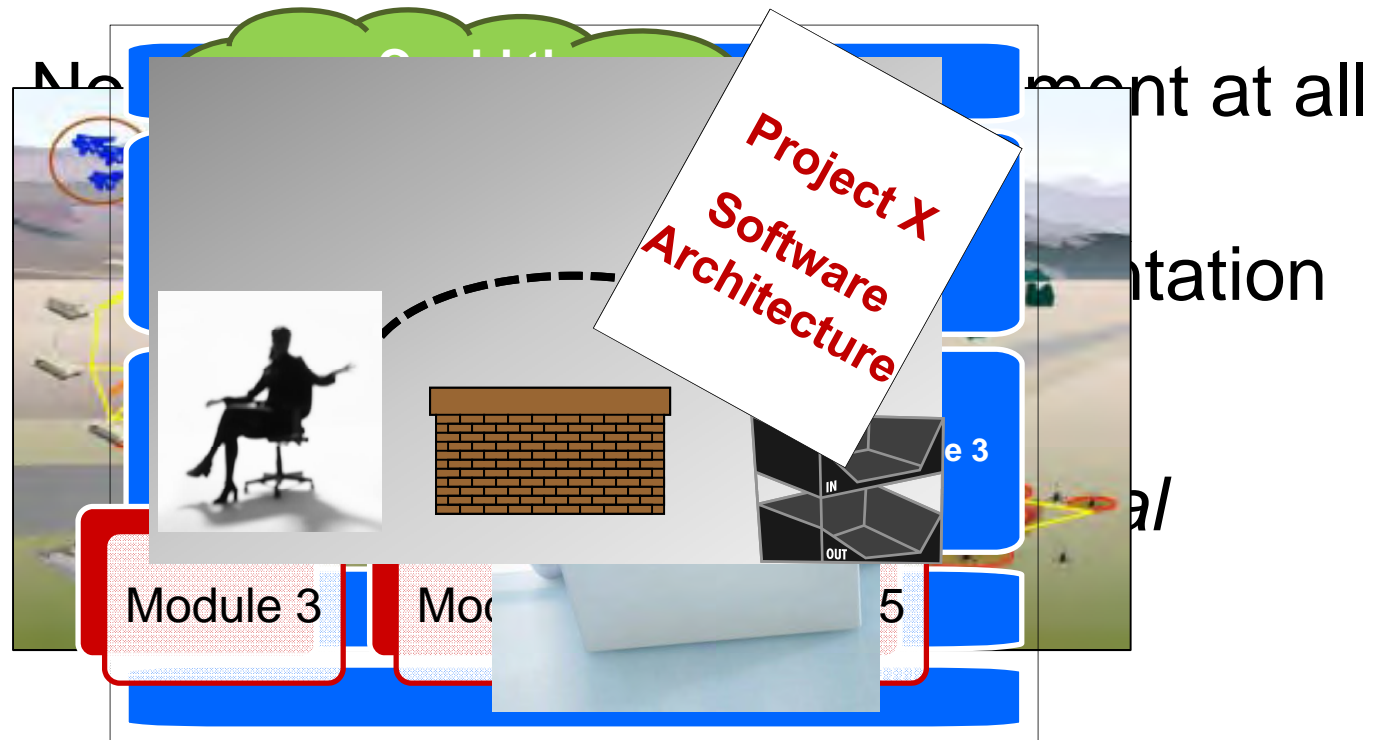
No architecture review, etc.

DoD Chief Information Officer (CIO) White Paper (2008)

- 3 root causes for architecture practice shortcomings across the DoD

  – Inability to leverage the benefits of an architecture due to inadequate training on the part of stakeholders or inadequate communication on the part of architects

  – Lack of incentives to encourage the professional growth of architects in the DoD

  – Lack of visibility into the existence or value of architecture training

The Army is aggressively tackling these issues (and more)…

The Army is Changing the Game

Army Strategic Software Improvement Program (ASSIP)

- A partnership between the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (OASA(ALT)) and the Software Engineering Institute (SEI)

  - Focusing on improving the Army's ability to acquire software-reliant systems

  - Promoting collaboration across the Army acquisition community and with sister services

One of ASSIP's major initiatives: leveraging software architecture in acquisition

- Education

- Application of proven architecture practices[1]

- Institutionalization: establishment of Chief Software Architects (CSWAs)

[1] Such as found in "A Proactive Means for Incorporating a Software Architecture Evaluation in a DoD System Acquisition", CMU/SEI-2009-TN-004

The Army is Building Expertise

ASSIP-sponsored training

- Leveraged SEI architecture curriculum
- Over 500 Army personnel trained
  - Plus, over 50 support contractors trained
- >30% have earned at least 1 certificate
  - Software Architecture Professional
  - ATAM Evaluator

	Other	PEO 1	PEO 2	PEO 3	PEO 4	PEO 5	PEO 6	PEO 7	PEO 8	PEO 9	PEO 10	PEO 11	Software Center 1	Software Center 2	Software Center 3	Software Center 4
■ Total Certificate Earners (SAP and/or ATAM Eval)	2	3	5	6	6	0	1	2	18	12	0	14	12	26	54	7
■ Total Participants	18	25	12	26	23	4	16	7	12	53	3	100	75	87	67	19
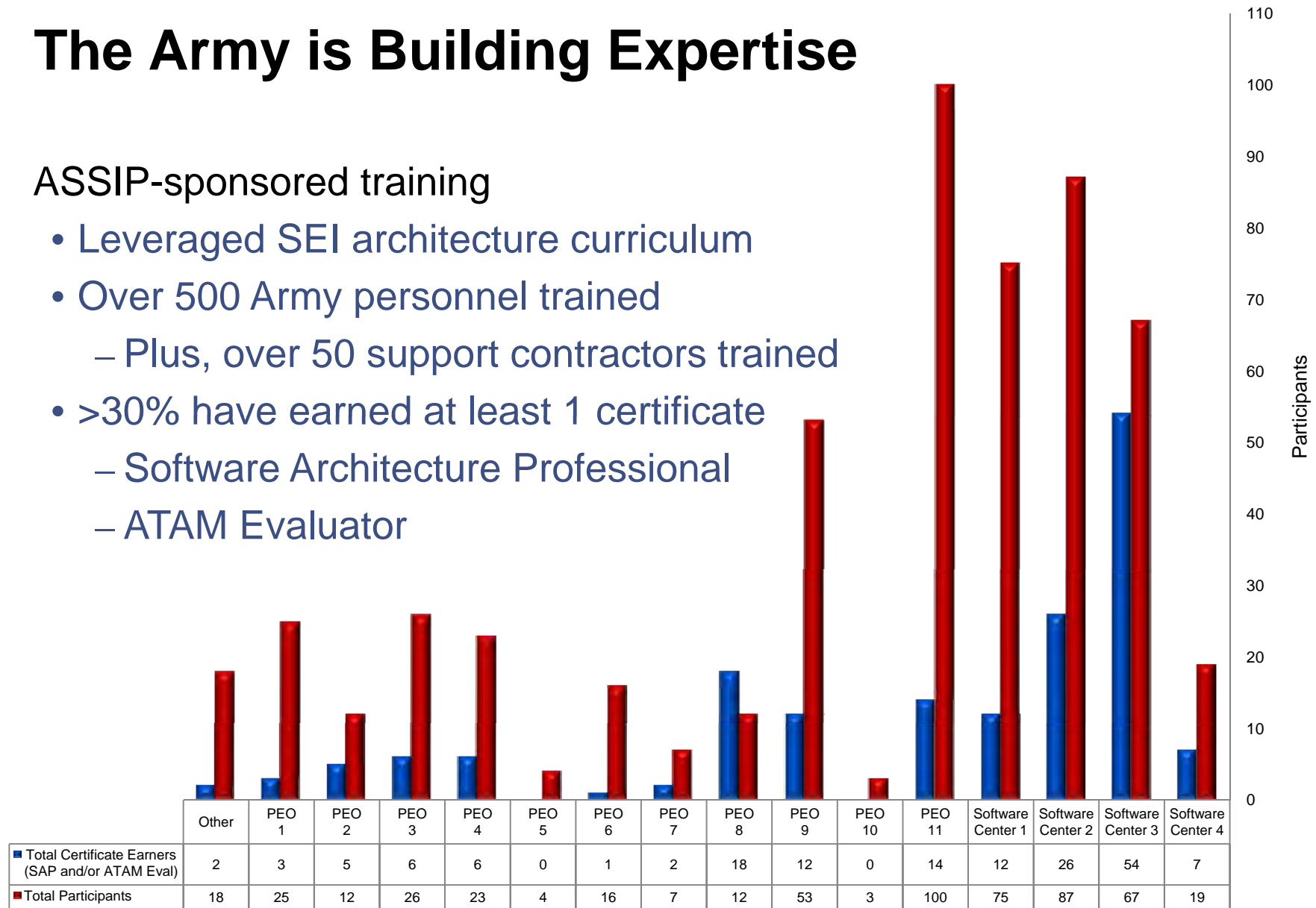
The Army is Sharing Architecture Knowledge

Since 2005, the Army has held annual workshops on software architecture and software product lines to:

- explore relationships among enterprise, SoS, system, and software architecture

- learn about best practices and recent developments in software architecture and software product lines

- share Army experiences in using software architecture and product line practices and how to apply them effectively in an acquisition context

- understand issues regarding broader use of software architecture and product line practices in the Army

A 2010 "hands-on" workshop is being planned to broaden exposure of Army organizations to architecture-centric practices

Through ASSIP, senior Army acquisition leaders discuss software issues, including architecture, three times per year

The Army is Using Architecture Practices

Since 2002, 14 Army projects have used

> the SEI Architecture Tradeoff Analysis Method® (ATAM®)

to conduct architecture evaluations and identify architectural risks and strengths

and/or

> the Quality Attribute Workshop (QAW)

to discover the quality attributes/non-functional requirements that drive system design

Army Project (in alphabetical order)	ATAM	QAW
Aerial Common Sensor	✓	✓
Army Battle Command System		✓
Command Post of the Future	✓	
Common Avionics Architecture System	✓	
Distributed Common Ground Station – Army	✓	✓
Force XXI Command Brigade-and-Below	✓	
Future Combat Systems	✓	✓
Integrated Fired Control	✓	✓
Joint Tactical Common Operational Picture Workstation	✓	
Manned/Unmanned Common Architecture Program	✓	
Network Operations Data Product Development Environment		✓
One Semi-Automated Forces	✓	
Sequoyah		✓
Warfighter Information Network – Tactical	✓	

Results of 2009 survey of 12 Army projects that employed ATAM/QAW[2]


Artifact Improvement
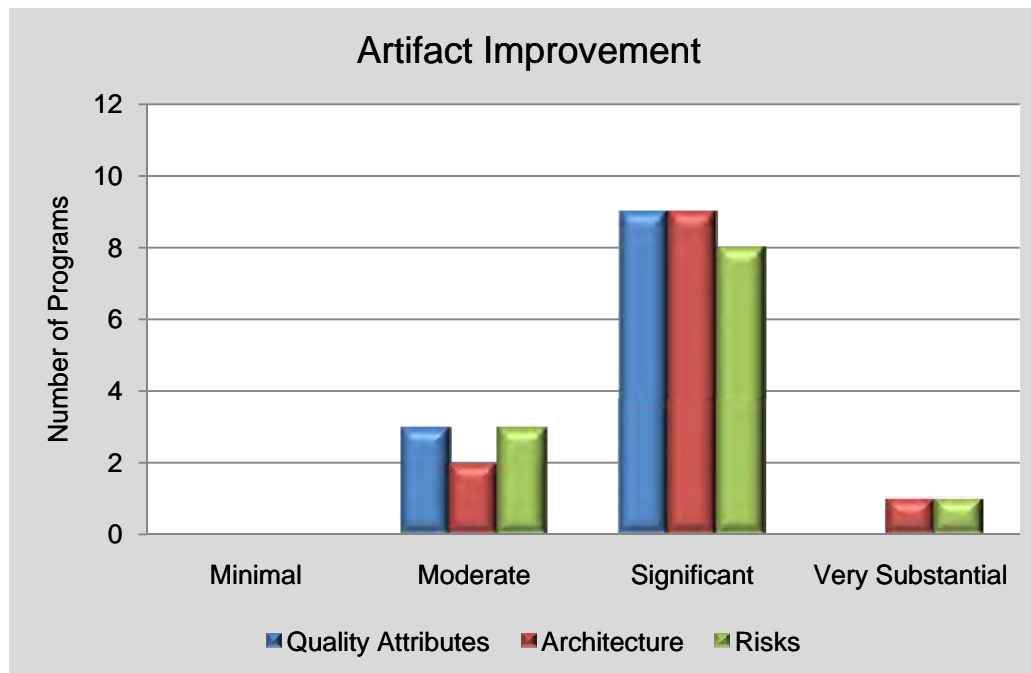
- Most reported *significant* improvement in their architecturally-significant artifacts

- Architecture teams were able to achieve understanding of stakeholder expectations and the implications of architectural decisions on user needs

[2] Source: Impact of Army Architecture Evaluations, CMU/SEI-2009-SR-007

Results of 2009 survey of 12 Army projects that employed ATAM/QAW

- Majority reported *very substantial* or *significant* improvement in stakeholder communication

- Stakeholders, collectively, are able to achieve a common understanding of the system under development
    - Increases likelihood that product will address expectations/user needs
    - Improves chances for program success

Communication Improvement

(Horizontal bar chart, x-axis "Number of Programs" from 0 to 12)

Category	Number of Programs
Very Substantial	7
Significant	4
Moderate	0
Minimal	1
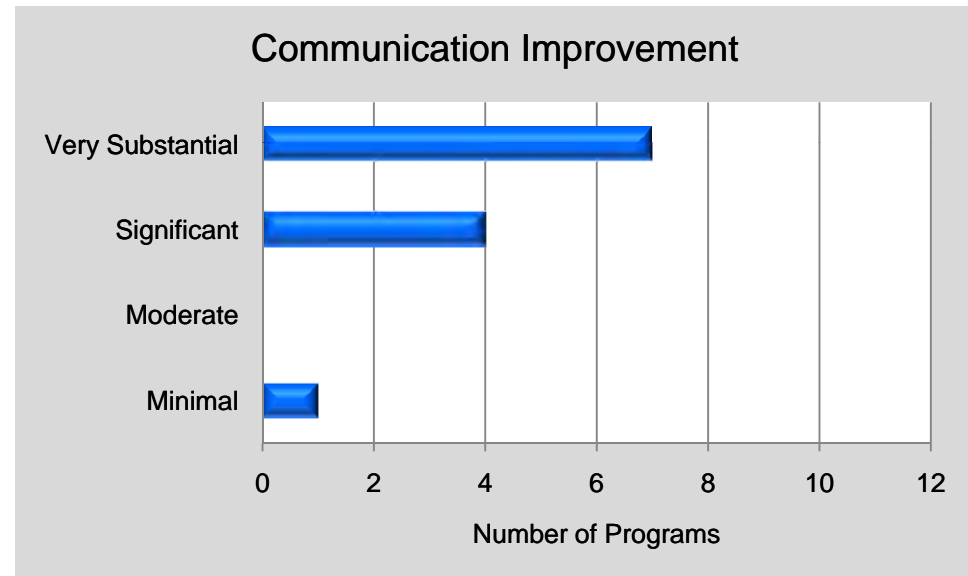
The Army has Established Chief SW Architects

Policy set by the OASA(ALT) in May 2009: "*All PEOs will appoint a Chief Software Architect*"

- CSWAs will provide oversight and management of software development within each PEO's portfolio of programs

- CSWAs will provide guidance for software architecture design *and* reviews
    - ensure consistent implementation of best practices and standards
    - ensure systems engineering plan considers software engineering practices

- CSWAs will complete the equivalent of the SEI software architecture course series

ASSIP is sponsoring workshops to help each CSWA get started and develop a comprehensive plan

The Army CSWAs Have Set Their Own Goals

Establish infrastructures in the PEO environment to support software objectives
- Issue guidance to the PMs on software architecture requirements
- Leverage the skills of the systems and software engineers across the organization

Support PMs in their software life-cycle processes
- Monitor software architecture throughout the acquisition life cycle to identify/mitigate risks, link components to business drivers, and focus on stakeholder requirements
- Assess and evaluate software cost estimates in a system life cycle context
- Review and endorse System Engineering Plans (SEPs) with the Chief System Engineer to leverage standards and ensure appropriate architecture-centric practices

Utilize software architecture and data interchange standards to minimize integration/interoperability challenges
- Ensure development of software architectures in a system of systems context to address interoperability and manage software system life-cycle
- Ensure program NR-KPP are understood and well defined

Take part in Communities of Interest (COIs) across the Army PEO portfolio and DISA forums to exploit commonality and integration to the GIG

Institutionalization is a Long Road

Pro-active planning for architecture-centric practices works best

- the norm has been reactive, opportunistic collaborations that lead to poor cooperation and lack of follow-through on findings

- inadequate planning leads to mis-timed architecture evaluations that preclude achieving full benefits

Establishing CSWAs is a good step toward institutionalization, but experience has shown that:

- developing an informed, comprehensive approach to software acquisition within a PEO organization will take time

- striking a balance between authority and influence is crucial

- having dual hats or significant other responsibilities will limit effectiveness

There Are Still More Opportunities

Through ASSIP, the CSWAs may explore Army-wide acquisition improvements such as:

- making software architecture evaluations standard practice

- requiring demonstrated architecture competency in responses to system acquisition RfPs

- achieving consensus on what system and software architecture documentation is most appropriate and cost effective

- increasing synergy and coherence between systems and software engineering acquisition practices

The CSWAs & ASSIP give the Army a vehicle for instilling architecture-centric practices in acquisition

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Acronyms

ASSIP	Army Strategic Software Improvement Program	MIT	Massachusetts Institute of Technology
ATAM	Architecture Tradeoff Analysis Method	NASA	National Aeronautics and Space Administration
CIO	Chief Information Officer	OASA(ALT)	Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology
COI	Community of Interest	PEO	Program Executive Office Program Executive Officer
CSWA	Chief Software Architect	PM	Program Manager
DISA	Defense Information Systems Agency	QAW	Quality Attribute Workshop
DoD	Department of Defense	RfP	Request for Proposal
FBCB2	Force XXI Battle Command Brigade and Below	SEI	Software Engineering Institute
GAO	Government Accountability Office	SEP	System Engineering Plan
GIG	Global Information Grid	SoS	System of Systems